INSTRUCTIONS FOR THE OPERATION, CARE, AND REPAIR

OF

PUMPS

(Revised December, 1929)

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CHAPTER 14.

PUMPS.

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Section I.—Reciprocating Pumps.

Part 1.—Operation.

Steps in starting a reciprocating pump.

14–1. To start a reciprocating pump, proceed as follows:

1. Oil the pins of the steam valve operating gear and set up on all grease cups.
2. Open the water end valves.
   (*a*) Suction.
   (*b*) Discharge.
3. Open the cut-out (or root) valve in the—
   (*a*) Exhaust line.
   (*b*) Steam line.
4. Open the steam cylinder drains.
   (*a*) Top.
   (*b*) Bottom.
5. Open the cushioning valves.
   (*a*) Top.
   (*b*) Bottom.
6. Open the exhaust valve at pump.
7. Crack the throttle valve (and open slowly so as to admit steam and warm up gradually).
8. Close the steam cylinder drains (after the pump makes a few strokes and the steam cylinder is clear of water).
9. Bring the pump up to the proper speed by sufficiently opening the throttle valve.

10. Close the cushioning valves until such adjustment is obtained that permits silent and smooth working of the pump (i. e., no knocking at the end of the stroke and at the same time the speed of the pump is not reduced too much at the end of the stroke).

11. Such additional instructions found necessary by experience with a particular design of pump will be added hereto by the engineer officer.

Steps in stopping and securing a pump.

14–2. To stop and to secure proceed as follows:

1. Close the throttle valve.
2. Close the exhaust.
3. Open the cylinder drains.
   (*a*) Top.
   (*b*) Bottom.
4. Close the water end suction valve.
5. Close the water end discharge valve.
6. Close the steam and exhaust cut-out valves (root valves).
7. After the steam cylinder is drained, close the steam cylinder drains.

Steps to take on failure to start.

14–3. If a pump fails to start, proceed as follows:

1. Secure the pump. Do not attempt to adjust the tappet collars.
2. Examine the discharge and the exhaust line for closed valves or for a valve disc that has become detached from its stem. If none are found closed—
3. The plunger or steam piston may be frozen, particularly if the pump has not been in service for some time; jack the pump with a bar to determine if there is excessive friction; if so the trouble probably lies here. (See Art. 14–98 (2).)
4. Disconnect the auxiliary valve stem from the operating gear without disarranging the adjustment of the tappet collars. Open the exhaust, suction, and discharge valves and then crack the throttle. Work the auxiliary valve by hand (the auxiliary valve should work *freely* by hand). Should the pumps still refuse to start—
5. Secure the pump. Remove the valve chest cover and examine the main valve to see if it has overridden or stuck.
6. If the pump can not now be started, a complete overhaul of the working parts of the steam end is necessary to stop steam leakage (either in steam piston or valves), the most probable cause of the pump not starting.

14–4. The main features in the operation of a reciprocating pump, with the principal causes of trouble and the remedy therefor, are enumerated below:

1. Keep the pump running at *full* stroke. (Do not alter the setting of the tappet collars when the pump fails to run smoothly without orders from the engineer officer.)
2. Oil frequently the pins of the valve-operating gear.

Jerky operation.

3. Jerky operation on starting is a failure to take suction. To correct this proceed as follows:

(*a*) See that all stop or check valves in the suction line are open and that the line is clear of obstructions.

(*b*) When a feed pump is vapor bound, take a suction from reserve feed tanks until pump is cooled off or turn a hose on the water end. (See Art. 14–31.) If a hot well pump is fitted, speed it up.

(*c*) Pumps having a suction lift, as bilge pumps, may require priming before they will take suction. Salt-water pumps can usually be primed from the sea by opening the sea suction valve for a short interval.

Loss of discharge pressure.

4. (*a*) If a pump races without appreciably increasing the discharge pressure, such racing is caused by a leaky plunger, leaky, broken, or stuck valve in the water end or by air being admitted through open or leaky valves in the suction line. Stop the pump as soon as practicable in order to ascertain and correct the trouble.

(*b*) Should a pump, which has been running properly, suddenly lose pressure on one stroke, look for a broken valve at once. Great loss of efficiency results from leaky suction and discharge valves, and leaky plungers. (See Arts. 14–26 and 14–27 in regard to proper adjustment of valve guards and valves so as to prevent leakage.) Previous experience with a particular type of pump may be taken as a guide in deciding where to look for the trouble. Under ordinary conditions, the first investigation should be of the most accessible parts.

Jerky operation of air pump.

5. When an *air pump* works with a *jerky* motion, troubles are indicated as follows:

(*a*) The vacuum gauge moving with the pump stroke points to damage to the foot (suction) valves.

(*b*) When vacuum drops and pump races, look for damage to the bucket valves.

(*c*) When vacuum is reduced and the pump works in jerks, look for damage to the discharge valves.

(*d*) If the pump is of the vertical type and works except for an occasional short stroke, set up on the auxiliary valve stuffing box to prevent the valve being operated by the weight of the operating gear and thereby reversing the pump.

Pounding in water end.

6. To stop *pounding* in the water end of a pump having a considerable suction head— (See Art. 14–29.)

(*a*) Throttle the suction slightly; or, better still—

(*b*) Install heavier springs in the suction valves.

7. Pounding in the water end of other pumps usually denotes improper cushioning or a loose plunger and can be stopped by—

(*a*) Partially closing the steam end cushioning valves, which, when a pump is running at high speed, should be tightly closed. If this fails to stop the pounding—

(*b*) Examine the plunger, or the plunger rod where it is secured in the crosshead, for lost motion, look for a loose nest of valves, loose zinc plates, or—

(*c*) If the pump is not fitted with an air chamber on the suction side and pounds, a snifting valve installed on the suction side usually stops the pounding.

Groaning in water end.

8. Groaning in the water end is generally due to the packing being too tight, but may be the result of a broken follower or the breaking of other parts. Therefore the pump should be stopped and examined at once. Failure to investigate usually results in at least a scored cylinder.

Erratic operation.

9. When a pump operates erratically, sticks in any part of the stroke, or stops frequently with the throttle valve opened the proper amount, the cause is in the steam end and is probably due to one or more of the following defects:

NOTE:—In the following articles, the valve which is actuated by the valve gear will be referred to as the "auxiliary valve"; the valve moved by the piston plunger in the steam chest and which controls the steam to the steam cylinder, as the "main valve"; and the piston valve which moves the main valve, as the "supplementary valve."

(*a*) *Lost motion* in the auxiliary valve operating gear (it should be removed by rebushing and, if necessary, renewing the pin at the affected part).

(*b*) Failure of the auxiliary valve to bear on the face of the back of the main valve in the newer type Blake pump and in pumps with similar valve gear. (This fault is overcome by the insertion of a liner between the valve and the valve stem.)

(*c*) *Leakage of steam* by the main or auxiliary valve due to wear of either. (To remedy spot in the defective valve on its seat.)

(*d*) *Leakage of steam by* or *sticking of* the auxiliary steam cylinder plunger. (To stop this it is necessary either to rebore the auxiliary steam cylinder or renew or refit the plunger rings.)

(*e*) *Excessive leakage by* the steam piston rings. (To prevent this leakage it may be necessary to rebore the steam cylinder, renew the rings, or both.) In some cases where split rings are fitted, the leakage can be partially stopped by taking out the rings and peening them.

Knocking in steam end.

10. *Knocking* in a steam cylinder is indicative of loose piston rings, a piston loose on the rod, or the auxiliary steam cylinder piston knocking against the cylinder heads on account of too thin gaskets or a change in the relative size of steam ports. (The pump should be stopped at once and the exact trouble discovered by measurement and examination, then rectified.)

Groaning in steam end.

11. *Groaning* in the steam cylinder is usually due to steam getting behind the steam piston rings and forcing them out against the cylinder walls, to broken rings, or to the cylinders being out of alignment; the trouble, unless immediately rectified, is liable to result in scoring the cylinder walls. If a pump has been idle for a long period, rust sometimes forms and may cause groaning when the pump is started up.

Worn piston rings.

12. Should the pump stop when going very slowly, it may be due to steam passing worn piston rings. The appearance of a good bearing on the piston rings does not necessarily indicate a good fit. They should be removed from the cylinder so that measurements of both rings and cylinder may be checked for excessive clearance. An air pump when run too slowly is likely to stop. The reason for this is that most of the work done by the pump occurs at the end of the stroke, and in slowing it down the throttle may be closed so much that there is not sufficient steam to do the work of finishing the stroke.

13. Should a pump stop or stick, *do not jack it with steam turned on*—to do so may cause serious damage to it. (See Art. 14–98 (2).)

PART 2.—CARE.

Lubrication.

14–5. Use a very small amount of cylinder oil on the steam ends of the rods, and lubricate all outside moving parts with mineral oil. Use no oil in steam or water cylinders, or valve chest, except if using superheated steam on the auxiliary line, when a little internal lubrication of the valve chest may be necessary.

Jacking.

14–6. All pumps should be moved daily; oftener when there is possibility of freezing. A pointer should be fitted on the crosshead and seven marks made on a rod which the pointer will pass. Each of these marks should be labeled with one of the days of the week; it is then always easy to see if the pumps have been moved. (See Art. 14–98 (4).) If a pointer is not installed, the engineer officer should

examine the general condition of the piston and plunger rods which serve as a guide as to whether or not the pump has been jacked over.

Gland leakage.

14–7. Exercise great care in setting up on glands; if the two sides are set up unequally the gland becomes tilted and scores the rod, and sometimes breaks the gland itself. If a gland is set up too hard it will probably score the rod; if a gland continues to leak after it has been given a few turns on the nuts the best thing to do is to let it alone until the pump can be shut down. Then examine to see if the throat bushing is too large, due to the rod having been turned down; if the gland has the proper bevel, or if only new packing is needed. Particular attention shall be given to those connected with low-pressure cylinders and other parts working below the atmospheric pressure to prevent not only loss of vacuum but the admission of grease into the cylinder and of air into the feed system.

Prevention of rusting of steam valve.

14–8. Remove the steam valves and valve gear frequently and clean them with kerosene. Before replacing coat them thinly with mineral oil.

Adjustment of stroke.

14–9. (1) Pumps should be made to run with the full length of stroke, which will insure that the piston travels a little beyond the counter bore (full stroke is that stamped on the data plate). This insures steam economy and better operation of the pump. When full stroke can not be obtained, it invariably means that something is wrong, either with the design or the adjustment of the pump. A short stroke results in incomplete cushioning and the formation of shoulders in the cylinders and valve chests with resultant breakage of rings and followers. It should not be necessary to continually keep moving the collars while the pump is running; if found necessary to do so, something is wrong with the pump and it should be dismantled and the interior parts examined.

(2) A device that permits of ready checking the stroke is "a stroke-gauge" consisting of a small sheet-metal pointer secured to the crosshead which, when the pump is running at full stroke, points squarely to outer marks on the pump columns.

(3) (*a*) The proper valve setting must be carefully determined to make a pump take full stroke. In this connection the following thumb rule for setting steam valves will be found to be satisfactory: Place pistons in the centers of the cylinders or on half stroke and the valves the same. Then with the top collar all the way down to the tappet, the valve should be open at the top one-fourth inch and with the bottom collar all the way up to the tappet, the valve should be open one-fourth inch at the bottom; with the collars at equal distances from the tappets the valve should be at the center.

(*b*) Another method of setting valves is to place the piston and valve on the center, as before; then move each collar from the tappet one-half the width of the steam port. In the case of pumps where the tappet moves the full distance of the stroke, the distance from collar to tappet would be one-half stroke (steam-port opening).

(4) (*a*) To adjust the steam valves of a duplex pump drain the water and place one piston on its top striking point and by removing the steam-chest cover of the valve chest of the other piston, adjust and secure the valve to give an excess of one-eighth inch of a full bottom port opening; then put the piston on its bottom striking point and adjust and secure the valve of the other piston to give an excess of one-eighth inch of

full port opening at the top end. To set the other valve, repeat the operation with the other piston.

(*b*) Run the pump slowly with the throttle cracked, against little or no pressure and with the cushioning valves opened wide. The pistons should be striking on the cylinder heads; if they do not, there is some undue friction, possibly due to tight piston rod and plunger packing. Close down on the cushioning valves until the pump is running at the full length of stroke of both the steam pistons with a smoothness of reversal and no striking. Should it be impossible to obtain this smoothness of reversal, it may be necessary to alter slightly the adjustment of the valve-operating collars.

(*c*) To shorten the length and prevent excessive striking of the piston against the cylinder heads, the collars must be set closer together; to lengthen the stroke, set the collars farther apart. Care should be taken to move both collars the same amount, for otherwise stroke will be longer on one end than the other.

(*d*) After the valves have been set, trams should be made for the collars so they can be reset without removing the valve-chest covers. It is also advisable to drill holes in the tap screws of the collars and run a wire through them after they have been set; this will prevent inexperienced men from moving the collars.

(5) Of course, some pumps are not properly designed and, when adjusted to give full stroke at low speeds, will over ride and pound at full speed. The only remedy for this is to have two separate valve adjustments and two sets of cams, so that the valves can be set quickly.

After a pump runs on short stroke for any length of time, difficulty may be had in making the pump take a full stroke, due to shoulders having been worn in the valve seat. These shoulders will have to be removed before full stroke can be obtained.

Examination of water valves.

14–10. For satisfactory and economical running of pumps it is essential that the valves should be absolutely tight. The water valves in salt water service pumps and valves in other pumps should be examined quarterly and all foreign matter on valves, valve stems, and valve springs removed.

Test for tightness of water end.

14–11. In securing feed pumps they should be tested for defects in the following manner: Bring the pump up to 30 or 40 pounds above the boiler pressure, close the discharge and shut steam off the pump; if the pressure holds, then the water end is tight; if the pressure falls, then the water end should be examined for the following:

1. Leaky water piston.
2. Leaky valves.
3. Weak relief valve spring.
4. Leaky joints.
5. Leaking stuffing box.
6. Defects in the water chamber which allow water to pass.

PART 3.—REPAIRS.

14–12. (1) When repairs are undertaken, it is essential that each part which may be in need of attention and which may contribute to poor operation should be put in proper condition. Therefore, a repair guide list is suggested for use. The repair guide list should be used for partial or complete overhaul. When a partial overhaul only is undertaken, each item on the list on which no work is done should be checked "Not done," meaning that the part involved has been inspected or at least

Repair guide list.

considered and work found impracticable or unnecessary. As is often the case, information of negative character is nearly equal in value to that of positive character. Upon completion of work, the repair guide list should be preserved as a record of conditions found, data taken, and work done. It will then be available for use when next overhaul is started.

(2) The series of guide lists would form a most complete history, made with minimum clerical effort, and would contain essential dimensions. The repair guide list herein shown can be used in the form shown for the majority of service pumps and is illustrative of what a form prepared for a special pump should be like. The lists should be printed if practicable in sufficient numbers to be available when needed. In all work on pumps, small parts, bolts, and nuts removed should be collected in buckets, or other receptacles, to prevent their getting adrift. Clean them and make inspections of pump interiors during and before final reassembly to insure that no loose material is adrift therein as well as to avoid casualty.

14–13.

..... *Pumps (reciprocating).*

Kind ..... *Size* .....

Date .....

	Done.	Not done
1. Assemble *drawings.*		
2. Collect *previous data.*		
3. I. Water end—Condition, amount lift; tension springs, etc.:		
(a) Valves.....		
(b) Valve guards.....		
(c) Valve springs.....		
II. Machine work (or renewals)—Fitting and assembly:		
(a) Valve seats.....		
(b) Valve guards.....		
(c) Valves.....		
4. Steam valve operating gear (see 9, III):		
(a) Condition.....		
(b) Machine work (or renewals).....		
(c) New bushings.....		
5. Steam valves and valve cylinders.....		
I. (a) Auxiliary steam cylinder, diameter (inches)—		

	Top.	Middle.	Bottom.
Vertically.....	.....	.....	.....
Horizontally.....	.....	.....	.....

(b) Piston diameters—		
Top.....		
Bottom.....		
(c) Ring diameters—		
Top.....		
Bottom.....		
II. Machine work (or renewals)—Fitting:		
(a) Auxiliary steam cylinder, finished diameter (inches)—		

	Top.	Middle.	Bottom.
Vertically.....	.....	.....	.....
Horizontally.....	.....	.....	.....

(b) Piston (if solid), finished diameter.....		
(c) Main valve spotted in.....		
(d) Auxiliary valve spotted in.....		
III. (a) Patterns (paper) of main valve ports.....		
Check action main valve.....		
(b) Patterns (paper) of auxiliary valve ports.....		
Check action control valve.....		
IV. (a) Reassemble steam valves.....		
(b) Cut and fit gaskets.....		
(c) Do not secure auxiliary valve chest cover (see step 9, IV).....		

	Done.	Not done.
6. Water cylinder:		
I. (a) Remove piston follower, condition		
(b) Rings (or packing), condition		
II. (a) Disconnect water end piston (or plunger) rod at crosshead		
(b) Remove water end piston (or plunger)		
(c) Record cylinder diameters (inches)—		

	Top.	Middle.	Bottom.
Fore and aft			
Athwartship			

(d) Water end piston (or plunger), diameter		
(e) Follower, diameter		
(f) Ring diameter (if metal)		
III. Machine work—Water end cylinder, etc.—		
(a) Water cylinder, finished diameter		
(b) Water end piston (or plunger), diameter		
(c) Follower, diameter		
(d) Rings, diameter		
(e) Water end piston (or plunger) rod, diameter		
(f) Water end piston (or plunger) rod, length		
(g) Water end piston (or plunger) rod, taper		
(h) Snifting valves		
(i) Relief valves		
7. Steam Cylinder:		
I. (a) Remove piston follower, condition		
(b) Piston rings, condition		
(c) Piston springs, condition		
II. (a) Disconnect piston rod at crosshead		
(b) Remove piston rod		
(c) Record cylinder diameters (inches)—		

	Top.	Middle.	Bottom.
Fore and aft			
Athwart ship			

(d) Steam piston diameter		
(e) Follower diameter		
(f) Ring diameter		
III. Machine work—Steam cylinder, etc.—		
(a) Steam cylinder, finished diameter		
(b) Steam piston, finished diameter		
(c) Follower, finished diameter		
(d) Rings, finished diameter		
(e) Springs, studs, etc		
(f) Steam piston rod, diameter		
(g) Steam piston rod, length		
(h) Steam piston rod, fitting in piston		
(i) Cushioning valves		
8. Alignment:		
I. Center line through water cylinder counterbores extending line through and above the steam cylinders.		
II. Take measurements—		

	Fore and aft.	Athwart ship.
Water cylinder bottom		
Water cylinder top		
Steam cylinder top counterbore		
Steam cylinder top		
Steam cylinder bottom counterbore		
Steam cylinder bottom		

III. Adjust alignment by moving steam cylinder.		

	Done.	Not done.
9. Reassembly:		
I. Reassemble steam end, taking care to—		
(a) Secure piston on piston rod		
(b) Secure piston rod in crosshead		
(c) Adjust piston ring springs		
(d) Secure follower on piston		
(e) Repack piston rod stuffing box		
(f) Renew cylinder head gasket		
II. Reassemble water end, taking care to—.		
(a) Secure water end piston (or plunger) on rod		
(b) Secure water end piston (or plunger) rod in crosshead		
(c) Adjust (piston ring) packing		
(d) Secure follower		
(e) Repack water end piston rod stuffing box		
(f) Renew cylinder head gasket		
III. (a) Assemble steam valve operating gear		
(b) Auxiliary valve should move easily when stem is moved by hand		
IV. Set steam valves.		
10. Tests and final adjustments:		
I. Light load test for—		
(a) Smoothness of operation		
(b) Length of stroke		
II. (a) Close discharge valve—pump should practically stop		
(b) Set relief valve		
III. (a) Full load test		
(b) Adjust cushioning valves		

General.

14–14. If a pump works badly and is in need of repair, do not touch the steam end until a thorough investigation shows that the trouble is not at the water end. Most pump troubles are due to fouled water cylinder, worn valves, or conditions in the water pipe connections outside the pump.

Assemble drawings.

14–15. (1) When repairing or making an interior examination of a pump, it is essential that all drawings and available dimensional data relative thereto be at hand. It is not infrequent that, after overhaul, such important dimensions as width of, and distance between, steam ports, length of rods, and of steam valves, and diameter of pistons, become altered, resulting in poor operation. Such poor operation will naturally continue in spite of other major repairs unless the real cause of trouble is rectified.

(2) Whenever reciprocating engines or pumps are opened up for repairs and at least annually, micrometer caliper measurements shall be taken of the cylinders and valve chests on the fore and aft and athwartships diameters at the top, middle, and bottom and the results recorded on the machinery history card, with an accompanying diagrammatic sketch showing measurements obtained and the date on which they were made.

Scored water cylinder.

14–16. The fact that a water cylinder is scored does not warrant reboring the liner or a renewal of same. Scores should be smoothed up by stoning to reduce leakage and wear on the packing. When the scoring is of such extensive nature that the leakage is excessive and the packing soon wears out, reboring or renewal of the liner should then be considered. The tolerances in wear of the water cylinder before reboring should be undertaken, and the tolerances allowed in boring the cylinder will be tabulated in chapter 39.

Loose pistons.

14–17. Steam and water pistons frequently work loose on the rods; this fault is generally due to poor workmanship and assembly or to the rod being so fitted that the shoulder brings up against the piston without giving a proper bearing surface for the taper part of the rod. The piston should fit within $\frac{1}{32}$ of an inch of the shoulder when set up hand tight, and should then be forced tightly against the shoulder by the securing nut. A small amount of foreign matter on the tapered part of the rod

will prevent the piston being brought firmly home. If a piston which has given trouble is properly refitted to the rod, the trouble will usually disappear. If a jamb nut is not fitted, one should be installed. Pump rods are sometimes screwed into the plunger and secured by a lock nut with a flat plate secured on top of the plunger to prevent the nut from backing off. This arrangement will still allow the nut and plunger to turn together and the plunger may back off and carry away. This trouble can be rectified by drilling a hole half in the rod and half in the nut, tapping the hole and screwing home a headless stud. A copper washer under the nut will help secure the nut from turning and getting loose on the rod.

Test for tightness. 14–18. The following method of testing the tightness of the piston in the cylinder has been used with success:

1. Remove the cylinder head. Shore the piston to prevent upward motion.

2. Connect a steam hose to the lower drain cock and gradually raise the pressure to the working pressure of the pump. If the rings are not tight steam will leak past them. It must be remembered that this test shows defects for only that part of the cylinder occupied by the piston. If measurements show that there is a great difference in size in various parts of the cylinder, the test should be repeated several times with the piston in a different part of the cylinder during each test.

Piston too small. 14–19. On reboring a water cylinder the piston and follower may be given so much clearance as to require renewal. As a temporary substitute, until a new piston and follower can be obtained, one of the following procedures may be employed:

(a) Install upper and lower rings of metal packing and insert soft packing between them.

(b) The piston and follower may be turned down, threaded, and a ring with same thread screwed tightly on. The outside diameter is then machined to fit the cylinder.

(c) The pistons of badly scored air pumps may be tinned, built up with babbitt, and then turned to the correct diameter.

Building up pistons. 14–20. Pistons may be built up by flowing on metal by the oxyacetylene method or electric welding. The piston is then machined to the proper fit.

Fitting soft packing. 14–21. (1) When packing a pump with Tuck's, flax, or other soft packing, soak the packing in water overnight before fitting and installing. Should an urgent demand for the pump not make this possible, the packing should be put in to fit loosely and allow for swelling. A failure to do this will surely result in the pump groaning or in a scored cylinder.

(2) Some pumps are fitted with lignum vitæ rings. When these rings become worn white metal rings should be substituted.

White metal rings. 14–22. If the pump is packed with white metal rings, their tightness can be improved by cutting water grooves about one-fourth inch apart, one-eighth inch wide, and one-sixteenth inch deep; these rings should be fitted tight enough so that they will drop slowly through the pump barrel due to their own weight. If the pump is packed with white metal split rings, they should be fitted with springs to hold them out and with a lock piece to prevent too great expansion. A satisfactory mixture for white metal consists of two parts tin and one part lead. These rings can be carried in the form of cast cylinders and a ring cut off when desired.

Metal rings. 14–23. Metal rings are sometimes very narrow and cut the cylinder. If wider rings are fitted the trouble generally stops. Sharp edges of rings should always be rounded with a file.

Breaking of followers.

14–24. Breaking of followers and bolts often occurs. This fault may be due to bad alignment, but it is also frequently due to a weak follower. Where this trouble is general in any one set of pumps on board ship it is very safe to assume that the followers are too weak; and a new and heavier follower should be tried on one of the pumps to see if it stops the trouble. This condition can sometimes be improved by fitting the piston with through bolts.

Follower too small.

14–25. In pumps where the follower is too small in diameter soft packing frequently rolls up between it and the cylinder, causing the follower to jamb and break.

Valves in water cylinder.

14–26. (1) For satisfactory and economical running of pumps it is essential that the valves in the water end should be absolutely tight. A good mixture for grinding-in valves consists of ground glass mixed with enough Albany grease to make the mixture pliable. Valves may be faced off in a lathe and then ground in on their seats by a simple device which consists of a rod of sufficient length slotted for a piece of metal which fits into a slot across the top of the valve. An ordinary bitstock can be used to do the grinding.

(2) It is sometimes desirable to take a cut off the valve seat without removing it. A simple cutter for this can be made with an extension for a bitstock similar to the grinding-in device. When flat valves are fitted, the seats may be trued up by using a small surface plate and spotting in the section on the surface plate.

(3) After the valves have been ground in, the whole pump should be tested by closing the discharge valve and cautiously putting steam on the pump. The pump should stall.

(4) At each examination try all sheet metal valve disks with a straightedge to see if they are true. Solid (cast) valves, if scored or warped, should be trued up in a lathe. Thin flat metal disks, if dished or warped, should be discarded and new ones installed, as they are liable to break after having been dished; the life of rubber valves can sometimes be prolonged by trimming and turning the valves and by inserting brass bushings.

(5) See that valve springs have the proper tension; this should be just great enough to insure a quick closing of the valve and it should be possible to lift the valve easily by hand. See that the springs are well secured by split pins. Adjust the valves to give the proper lift; it should be such that the circumferential opening is slightly greater than the clear opening through the seat, which ought never to be more than one-fourth of the diameter of the opening.

(6) Keep the valves clean; a light mineral oil makes a good cleanser and a lye or soda solution is good for removing caked or gummed oil from valves. In renewing valves, the new ones may be of slightly different thicknesses from the old, thus giving too much or too little lift; too little lift will usually cause the valves to squeal. In some pumps the valve seats are secured only by a taper fit. In such cases the valve seats should be forced home by a jack resting on the end of a reseater which in turn rests on the face of the valve seat. Should the seat work loose, slightly peen over the edge of the metal. In pumps that have the valve seats screwed into the pump diaphragm they should always be screwed in with white lead, otherwise it will be almost impossible to get them out.

(7) Several valves are sometimes secured in one plate. The plate is secured in the water valve chamber with a ground joint which is

difficult to make tight. If it is not tight water will leak under the joint and score it. This joint can be reseated with a ship's valve reseating machine, but a copper gasket seems to give better results.

(8) In Davidson pumps the discharge valve seats in the water end are sometimes secured to the pump diaphragm by shoulders on the valve stems which are screwed into the suction seats. These seats have small flanges under which gaskets are fitted. The manufacturer supplies rubber gaskets, but they are soon squeezed out and the seats will leak and hammer. Hard sheet packing will give better satisfaction than rubber, and lead better still if the water to be handled is cold. If sufficient time can be spared for it to set, red lead makes a satisfactory

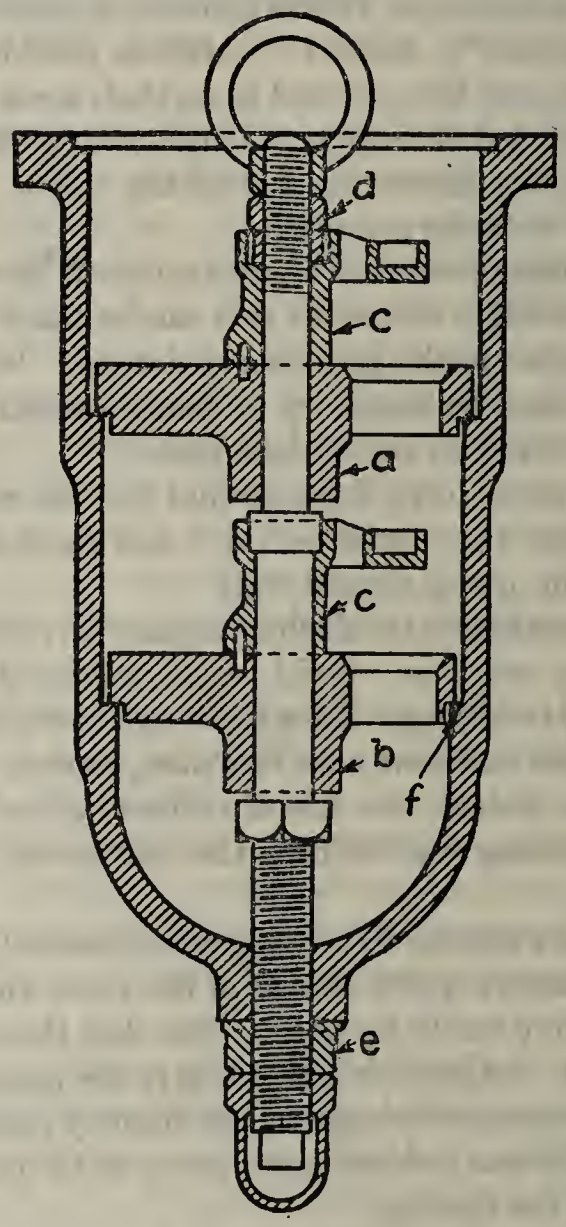


FIG. 14-1.

joint. In some cases this flange has given so much trouble that it has been necessary to fit new seats with a ground joint.

(9) In air pumps the stems of the valves are sometimes too loose a fit in the seat; this looseness results in allowing the stems to work, and the motion breaks the wire securing the stems together and then all of the stems back out. This fault can be remedied by refitting the stems.

(10) Most trouble with the water-end valves is experienced in the main feed pumps; frequently the stems of these valves will break so often as to become a serious matter. To remedy this fault cut the stem off the valve and turn a groove in the top of the valve for the spring to set in; the stem is pinned to the guard at sufficient height to

allow proper opening of the valve, and it then acts merely as a guide for the spring and a limiting device for the valve. It will be necessary to fit a new stem, as the old one will not be large enough to make a close fit in the guard.

Assembling valves.

14–27. (1) Great care should be exercised in assembling pumps after overhaul, otherwise the entire work on valves, etc., may be entirely lost. Valves, seats, stems, and springs should be marked before removal and replaced in the same places they are removed from.

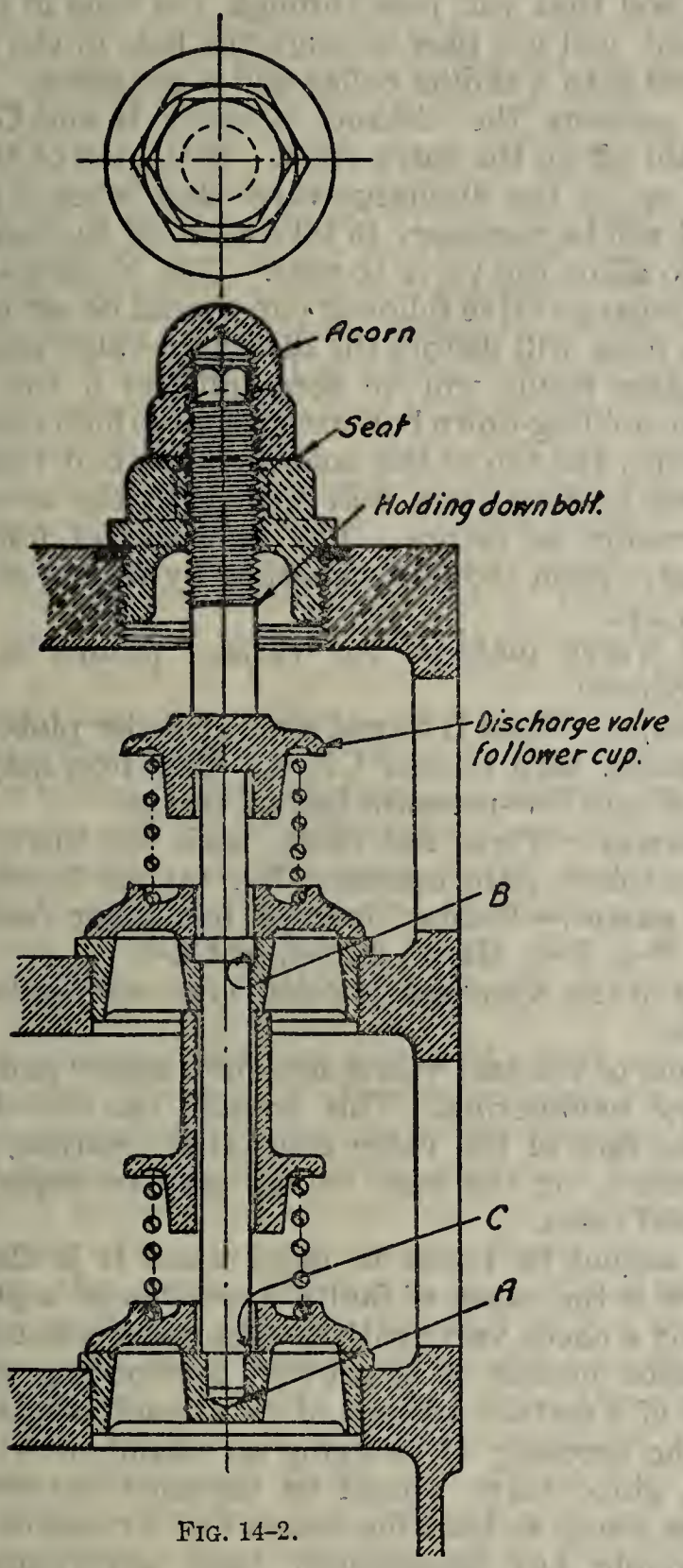


FIG. 14–2.

(2) As examples of importance of assembly, two cases are given:

(a) Figure 14–1 shows the valves of a Blake pump, valve-pot type. In assembling valve seats (*a*) and (*b*) with the valve guards (*c*) (*c*) were put in place and nut (*d*) set up before setting up the nut (*e*). This method drew (*a*) and (*b*) from their seats (*f*) (*f*) and water could flow between (*b*) and (*f*). This fault was corrected by reversing the operation; (*d*) was removed and (*e*) set up; when (*e*) was well home then (*d*) was set up, and there was no further trouble.

(b) Figure 14–2 shows the valves of a Blake pump, monochest type. In some cases it has been found that the end of the valve stem would take up on the bottom of the cup in the suction-valve seat at A, making the bottom of the stem collar have clearance between it and the corresponding seat in discharge valve seat at B. To insure proper seating at B, there should be a very small clearance between suction-valve seat and valve-stem seat at C, after the valve-stem collar has been properly seated at B. To get the distance between B and C, a dlstance gauge may be used; it may consist of a rod that will pass through the hole in the discharge-valve seat but will not pass through the hole in the suction-valve seat and fitted with a sliding collar and a set screw. This rod can be used to measure the distance between B and C and the distance then laid off on the valve stem. If the top of the valve-stem collar takes up on the discharge-valve disk when a proper seat is made at B, it will be necessary to take a cut off the top of the valve-stem collar to allow the valve to seat. The holding-down bolt on top of the discharge-valve follower cup should be set up hand tight, as too much force will distort the discharge-valve seat.

(c) The same result will be accomplished if the acorn is too shallow or the holding-down bolt extends up so high that, in screwing down the acorn, the top of the holding-down bolt binds; this fault will make the holding-down bolt turn with the acorn and cause excessive pressure as before. The tightness of follower cup on top of the valve stem should be checked by feeling as the bolt and acorn are set up.

Valve material. 14–28. (1) Valve material for various pumps on board ship shall be as follows:

(a) *Oil pumps.*—Class B forged steel or boiler plate, composition G, or cold rolled, hard temper CN–r. Cast iron may be used for lubricating oil and low-pressure fuel-oil pumps.

(b) *Air pumps.*—Three flat disks, each one thirty-second inch thick, of cold rolled, hard temper CN–r (about 18 scleroscope).

(c) *Other pumps.*—Rubber (except for boiler feed pumps) or composition P–c, P–r, Mn–C, Mn–r, or Cu–r.

(2) Valves of the *Kinghorn* or 3-disk type will not be used except on air pumps.

Cast valves. 14–29. Some of the cast valves are quite heavy and give trouble, due to heavy hammering. This trouble can be eliminated by cutting in the face of the valve concentric grooves, which give a cushioning effect, or the cast valves may be replaced by light bronze steepled disks.

Snifter valve. 14–30. It should be borne in mind when it is thought that a snifting valve is the cause of faulty operation of a pump that the valve is simply a check valve with an adjustable amount of opening, and its function usually is to prevent overloading and to permit the entrance of a certain amount of air at each stroke and thus do away with the necessity of charging air chambers with high pressure air. A globe valve should be installed between the check valve and the pump so that the amount of air can be regulated.

Relief line. 14–31. Trouble has occasionally been experienced with the relief line from the feed pumps. If this is piped back to the suction line close to the pump, in some cases when the relief valve lifts it will blow water away from the suction and cause the pump to become vapor-bound. This trouble can be stopped by taking the relief line back to the feed tank. (See Art. 14–98 (1).)

Blowing gaskets. 14–32. (1) For all cold-water pumps a sheet packing of rubber with cloth insertion is suitable for the water end bonnet. For the steam ends of all pumps and water ends of hot-water pumps compressed fiber packing is used for bonnet gaskets. When blowing

out of gaskets is experienced, the trouble can usually be eliminated by turning a shoulder on the head and counterboring the cylinder, so as to make a male and female joint; this shoulder will prevent the gasket from blowing out.

(2) On the water cylinder the head with the stuffing box gives the most trouble by blowing gaskets, on account of an alternate increase and decrease of pressure on the gasket, due to the motion of the rod; this will be aggravated if the stuffing box is unduly tight. A very reliable joint for this end can be made by fitting the shoulder as above described and then using a copper gasket cut out in one piece and put on by disconnecting the rod at the crosshead.

(3) In order to keep gaskets from blowing out through the forcing bolt holes, the forcing bolts should be kept in place.

Scores in steam cylinder.

14–33. Relatively small scores in a steam cylinder call for reboring on account of the cutting action of steam. Leakage past the steam piston is readily located by the dullness and discoloration of the cylinder walls. Having once obtained a foothold through the medium of a few scores, steam will gradually cut away cylinder walls until leakage by the piston becomes so excessive as to cause faulty operation of a pump. The spring in steam-piston rings will take up a certain amount of the wear in the steam cylinder, thereby permitting some wearing away before reboring the cylinder is necessary. The clearance tolerances allowed in boring pump steam cylinders before reboring is necessary will be tabulated in chapter 39.

The alignment of pumps.

14–34. Pumps must be kept in line, as failure to keep proper alignment is one of the greatest sources of trouble with pumps aboard ship and is one of the most serious defects. Pumps secured to a bulkhead are more apt to get out of alignment than those with an independent base and settings, such as air pumps. A pump may have been nicely aligned in the shop and then pulled out of line when it is bolted to the bulkhead, or, after it was secured the ship may have changed shape sufficiently to warp the bulkhead and cause the same result. If the pump is run in this condition, it usually results in scoring the rod and cylinders and breaking followers and bolts. The alignment of pumps should be tested occasionally by removing the piston and plunger and running a line through the cylinders; especially should this be done during the first year of commission of a new ship, and also if a pump is giving trouble by scoring the rod or cylinder or breaking followers.

Running a line.

14–35. A good method of running a line through the cylinders that greatly facilitates the work of realignment is to fasten one end of the line on a finger piece secured to the bottom of the water cylinder and the other on a temporary beam rigged above the steam cylinder; then center the line at the bottom and top of the water cylinder so that it becomes the axis of this cylinder. The steam cylinder can now be moved about and centered on the line without disturbing the centering of the line on the water cylinder.

Fitting metal rings.

14–36. (1) The troubles in the steam cylinder result chiefly from the rings. Leakage of steam past a ring dulls the rubbing surface of a ring which when tight has a highly polished oxidized finish. With split rings the steam may get in behind the rings and force them out against the cylinder, causing the pump to groan and cutting the cylinder and the rings. The remedy is to fit locking bolts which will allow the rings to open out only to the diameter of the cylinder; it will be necessary to readjust this ring as wear occurs. In aggravated cases relief has been obtained by turning a groove about one thirty-second inch deep and three-eighths inch wide about the middle of the ring and drilling one-eighth inch holes right through the ring. These holes will relieve the pressure of the steam. Diagonally cut split rings seem to give better

satisfaction than overlapping rings; the latter generally break at the corner after being in service a short time, although this trouble can be reduced by rounding the corners of the shoulders.

(2) The ideal split ring would be one which would just rest against the cylinder wall and prevent the leakage of all gas past it, but at the same time exert no lateral pressure against the wall. This method, however, is impractical, so resort is made to split rings. The method of fitting them to the cylinder varies in the different shops.

(3) The following procedure is one which is approved by the Bureau:

(*a*) In order that the ring may be under tension and still remain in close contact with the cylinder wall even after a little wear, and at the same time not allow too much leakage through the cut, a ring should be turned down before splitting to a diameter that is larger than that of the steam cylinder in which it is to be fitted by 0.010 of an inch for each inch of diameter of the cylinder. The ring should then be cut, and an amount taken out which is approximately twice the amount of the difference between the diameter of the rough turned ring and the diameter of the bore of the cylinder. A liner consisting of a piece of chart paper for the larger size and thinner paper for the smaller size pumps is now placed in the gap in the ring caused by the removal of the metal by splitting; the ring is secured on the face place of a lathe and turned to the exact diameter.

(*b*) When split rings can not be made to work, resort is usually had to a solid ring with grooves, but this is not very satisfactory, as it will leak as soon as it wears a little.

Tightness of steam valves

14–37. Flat steam valves should always be kept scraped true and the packing rings of piston valves kept free in the grooves. In scraping in flat steam slide valves, the strokes of the scraper should cross, in order that the scraper will not chatter on the narrow bridges between the ports, and thus cause steam leakage when the valves is in operation. It is highly important that all the steam valves should be kept tight, for, if the control valve leaks, the main steam valve will become steam bound and the pump will stop. In facing off the pilot-valve seat of a Blake pump care should be taken not to face off so much that the valve will not be able to seat itself. With the new Davidson valve gear, it is very important to keep the tapered pin in the small exhaust valve set up hard enough to insure a slight friction on the valve chest, otherwise the pin will get loose and the valve will float back and forth on the small play allowed it, and the pump will run on short stroke and frequently stop. This pin is intended to take up wear and will have to be adjusted occasionally. With the old Davidson gear of the cam and pin type, the best results are obtained by casehardening the cam and fitting the pin with a roller and keeping plenty of spares on hand. Main steam valves are frequently put together without lock nuts; in this case they usually fall to pieces after a short time; lock nuts should be fitted and set screws put in to hold the lock nuts.

Piston valves.

14–38. Piston valves are generally fitted with rings in the same manner as the steam piston, but these have sometimes given trouble which has been eliminated by carefully fitting a solid piston valve; however, this will not give satisfactory results if the valve wears much.

To check valve measurements.

14–39. As a result of the frequent spotting in of the main and auxiliary steam valves it may happen that the relative size and arrangement of ports openings become changed owing to irregular coring. An easy method to check the accuracy of the valve action is to cut paper pat-

terns of the valve and valve seat faces by laying the paper on the valve and peening with a hammer; sliding the pattern of the valve over that of the seat will show the exact laps, leads, and port openings, which can then be checked with the drawings.

Auxiliary steam cylinder.

14–40. The same care must be exercised in fitting the auxiliary steam cylinder, cylinder rings, and piston as is used in fitting the steam piston and cylinder.

Cushion valves.

14–41. The steam cylinders of certain types and sizes of our direct-acting pumps are fitted with cushion valves as shown in Figure 14–3. The purpose of these is to provide an adjustable steam cushion for the piston so as to insure a full-length working stroke and at the same time prevent the piston striking the cylinder heads when the pump is working under widely varying conditions of load.

Operation of cushion valves.

14–42. The manner in which these valves work is clearly shown by the sectional view, figure 14–3.

(1) A chamber (C), one at each end of the cylinder, forms a connection between the steam port (ST) and the exhaust port (EX). This connection can be shut off by means of the valve (V).

(2) As the piston (P) approaches the end of its stroke it covers the port (EX) through which the steam has been exhausting and confines the remaining steam in the space at the cylinder end, thus forming a steam cushion that prevents the piston from striking the head. The amount of this cushion is varied by opening or closing valve (V), the only means of escape for the confined steam being through chamber (C) to port (EX).

(3) The more valve (V) is open the longer the stroke will be.

(4) If the pump is running at a low speed or working under a heavy load, valves (V) should be open as much as possible without allowing piston to strike heads. If the pump is running at a high speed or working under light load, valves (V) must be closed more. The amount of steam cushion and consequently the length of stroke can be properly regulated under any conditions of running by the simple adjustment of these valves.

NOTE.—The valve gear of the pump should always be adjusted so that pistons will make as long stroke as possible without striking the heads while the cushion valves remain wide open. The cushion valves are then partly or wholly closed as the varying conditions of the load may demand.

Care of mechanism.

14–43. It is most important that all wear and lost motion be kept out of the steam valve operating mechanism. Failure to do this will cause the pump to operate in a faulty manner and perhaps to stick. Rebush and renew the pins as often as necessary; if the wear of the bushings occurs rapidly despite careful lubrication, it is best to bush the holes with tool-steel bushings.

Cracked cylinder or valve chest.

14–44 (1) A broken or cracked cast-iron pump cylinder and valve chest subject to low pressures has, as a temporary expedient, been repaired by fitting a sheet-iron casing loosely around the damaged part and filling in the intervening space (about 2 inches) with a rust joint mixture. If possible first calk annealed copper wire into the crack on the inside of the cylinder. Then strengthen the broken part, if practicable, by shrinking on an iron band around it; also holding it together by long stud bolts screwed into the flange at opposite ends of the cylinder. After this pack the rust mixture around the cylinder inside the sheet metal casing.

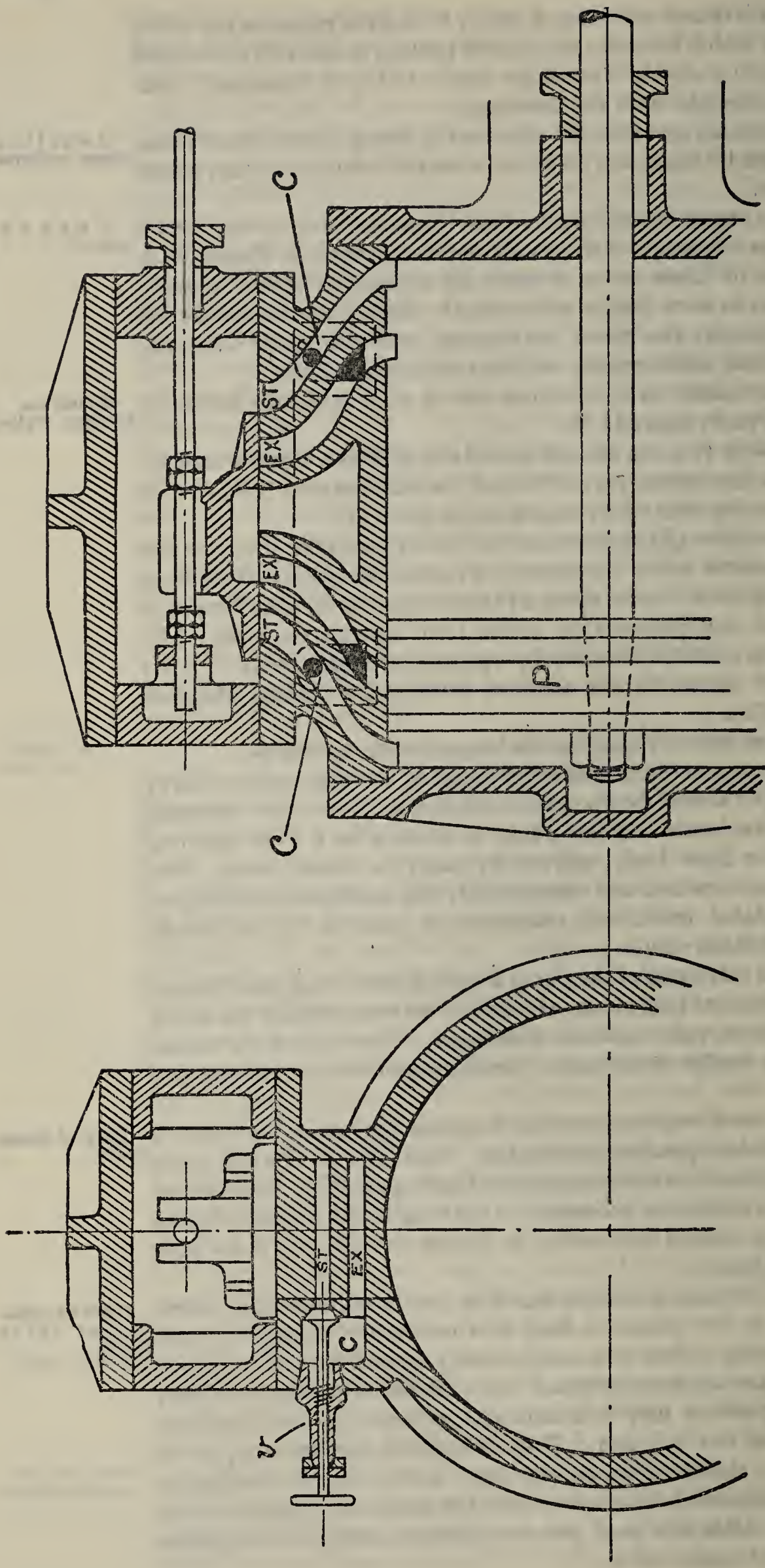


FIG. 14-3. Cushioning Valve.

(2) The rust mixture is made as follows:

(*a*) Mix dry—

1 pound of iron borings;
2 ounces of salammoniac powder;
1 ounce of flowers of sulphur powder.

(*b*) Mix with water to the consistency of mortar the mixture (*a*) above and add

20 pounds of iron borings.

(3) Apply and allow to set for 24 hours or until solid before using the injured machine. Concrete has been used in place of the rust mixture.

Telltale lights.

14–45. The installation aboard some ships makes it impossible for the throttle man to see whether or not his auxiliaries are running. To overcome this, telltale lights have been fitted up by putting a make-and-break connection on the air pump, main circulating pump, and lubricating-oil pump.

Section II.—Rotary Pumps.

A.—Centrifugal pumps.

Part I.—Operation.

Steps in starting.

14–46. To start a rotary pump proceed as follows:

1. Fill all oil cups and reservoirs. If lubricated by a detached pump, open and adjust all oil delivery valves at bearings.

2. Open the valves on pump and engine to the water or steam seals and stuffing boxes; if packed stuffing boxes are installed slack up all the glands so as to allow a reasonable amount of leakage.

3. Open the engine cut out (or root) valves in the—

(*a*) Steam line.
(*b*) Exhaust line.

4. Prime the pump.

5. Open the pump suction valve.

6. If the driving engine is of the reciprocating type, jack it into position for starting (one crank off dead center). Remove jacking bar. (See Art. 14–98 (2).)

7. Open the exhaust valve at the driving engine.

8. Open the driving engine drains.

9. Open the air cocks on the pump.

10. Crack the engine throttle valve to allow cylinder to warm up slowly; then slowly open it so as to admit steam gradually. Sometimes it will be necessary to give a quick opening to the throttle to get a reciprocating engine started, but care must be exercised if this is done to slow down at once after starting until engine is warmed up. In turbine driven pumps, difficulty is sometimes experienced in starting under load. When pump discharge is fitted with check valve, load may be reduced and pumps generally started by cracking the by-pass.

11. After all entrained air has escaped through the air cocks on the pump, close them.

12. Close the steam drains of the driving engine when the engine is clear of water.

13. When the pump has been brought up to proper speed open the discharge valve.

To stop and secure.

14. Such additional instructions as may be necessary for a particular pump will be added hereto by the engineer officer.

14–47. To stop and secure proceed as follows:

1. Close the engine throttle valve.
2. Close the engine exhaust valve.
3. Open the driving engine drains.
4. Close the pump suction valve.
5. Close the pump discharge valve.
6. Close all oil delivery valves at the bearings.
7. Close the valves in the stream or water lines to stuffing boxes or seals.
8. Close the driving engine steam and exhaust cut out or root valves.
9. After the driving engine is drained, close the steam drains.

Steps to take if pump does not build up.

14–48. The following are the steps to take on failure to build up a pressure or to discharge water when the discharge valve is opened and the pump speed is increased:

1. Stop the engine.
2. See that the pump is primed and *all air* has been expelled through the air cocks on the pump casing.
3. See that all valves in the pump suction line are open.
4. Start the pump again and, if when up to proper speed, the discharge pressure is not normal, the suction line may be clogged, the diffusion vanes clogged, an impeller broken, or air is being drawn in the suction line or into the casing—in which case stop the pump and notify the engineer officer at once.

Speed of pump.

14–49. The speed at which a centrifugal pump should be operated is dependent entirely upon its duty. The proper speed therefore must be determined from experience in operation of the particular pump. There are three laws that are in general applicable:

(1) The amount of circulating water needed for condensers, coolers, heaters, and other heat transfer apparatus is obtained when the temperature of the discharge is between 10° and 20° above or below, as the case may be, the temperature of the affected medium.

(2) A centrifugal pump should not be run at a speed that will partially or completely empty the suction pipe. If this rule is not observed the pump may become air bound, for a centrifugal pump running in air can not create sufficient vacuum to be self-priming. It is sometimes necessary that the pump be stopped and primed before again being run.

(3) A centrifugal pump single or multistage delivers at a pressure proportionate to the speed at which run, the higher the speed the greater the pressure, other conditions remaining the same.

Seals.

14–50. Particular care must be taken to insure that steam or water piping to seals or stuffing boxes is open and clear, otherwise there is a probability that the seal or the stuffing-box packing without this lubrication will wear very rapidly, that the shaft will be scored, and air will be drawn in. Therefore, when the pump is running, a little water or steam should be allowed to trickle out of the stuffing box or seal. If the shaft is packed with the stuffing-box type of packing the gland should be eased up until the lubricating and air sealing medium (usually water) trickles out. The efficiency of the seal should be tested with a candle flame to detect if air is being drawn into the pump. Such a leakage of air materially reduces the pump's efficiency.

14–51. The pet cocks at the highest point of the discharge and on the pump casing must be opened frequently to release entrained air. It is a good plan to keep them cracked so as to allow a continuous leakage of air and water, thereby insuring against a decrease in efficiency from pocketed air.

2. It is the practice when two or more centrifugal pumps are installed, to provide a gate and a check valve in the discharge of each pump, in order that an operating pump may not discharge through one not in operation should the gate valve be left open.

14–52. To operate the driving unit properly, reference must be made to the instructions elsewhere in the manual covering the type of machine in question.

Priming a centrifugal pump.

14–53. (1) Unless the suction water flows to the pump under a positive suction head, as in a main circulating pump, it is necessary to prime the pump before starting, that is *all air* in the pump casing must be forced out. Priming may be done by one of the following methods:

(*a*) Filling suction line and casing, putting fluid in them under pressure.

(*b*) Creating a vacuum in the casing so that water will fill the suction line and casing.

(2) The details may be accomplished in various ways, some of which are as follows:

(*a*) Filling the pump casing and suction line with water from the discharge line through a by-pass pipe around the discharge valve if the discharge line is filled at all times.

(*b*) Putting a vacuum on the top of the pump casing with the discharge valve closed to exhaust all contained air so water will rise through the suction pipe.

(*c*) Putting a steam or air ejector in the discharge line with the discharge valve open to accomplish the same reaults as in (*b*).

(*d*) Filling the pump and suction line from an independent source of supply as from a tank above it.

(*e*) When the suction *lift* is great it is advisable to install a check valve in the suction line below the water level in order that the suction pipe as well as the pump shall be primed.

14–54. If a pump does not build up a pressure after priming it should be stopped and primed again. While priming, the pump should be turned over by hand to allow air entrained in the impeller to escape.

PART 2.—CARE.

Zincs.

14–55. Zincs in condensers and pump casings, on ships where the main circulating pump discharges into the condenser head through a short and almost vertical discharge pipe, should be examined frequently for necessity of renewal. Under such condition of design it is not infrequent that the zincs deteriorate and break to pieces. The pieces may fall into the pump casing and damage the impeller. Brass washers fitted on the studs holding the zincs or through bolts with washers fitted instead of studs will usually eliminate the trouble.

Soft packing.

14–56. The soft packing in the pump stuffing boxes should be renewed about once in two months to make sure that it does not get hard and score the shaft. When repacking, a liberal use should be made of tallow for lubricating purposes.

Oil.

14–57. During each watch, frequent inspection of bearings of pumps in operation should be made. The oil in the lubricating

system should be renewed whenever it becomes emulsified or permeated with dirt and other foreign matter. Should the pump be allowed to run with this oil a rapid deterioration of the bearings will result.

Lubrication.

14–58. Before refilling a forced lubrication system with clean oil, kerosene should be pumped around it to remove any dirt or other foreign matter that may have collected. Immediately after removing the kerosene, the clean oil should be put in and pumped through the system to prevent rusting of journals.

Lignum - vitæ bushings.

14–59. The lignum-vitæ bushings used for the shaft bearings of centrifugal pumps sometimes wear rapidly and therefore put the pump out of alignment. They should be checked by ship's force annually or oftener if necessary, and new bushings fitted where necessary.

Care of engine and governor.

14–60. The care of the driving engine should be in accordance with instructions laid down elsewhere in the manual for the type of similar machine. For a turbine-driven pump, the care of the turbine and governing devices shall be in accordance with the instructions laid down in chapter 4 for turbine-driven blowers.

PART 3.—REPAIRS.

Repair guide lists.

14–61.—Repair guide lists.

.....*Centrifugal pump.*

Kind..... *Size*.....

Date.....

This list is intended to cover the repairs to the pump proper. Those on the driving engine, which should be undertaken simultaneously, are covered by those listed for the general class of machinery under which the driving engine belongs.

	Done.	Not done.
1. Assemble *drawings.*		
2. Collect *previous data.*		
3. Open up—		
(a) Stuffing boxes and seals.....		
(b) Pump casing.....		
(c) Bearings.....		
4. Stuffing boxes and seals:		
(a) Condition.....		
(b) Machine work (or renewals).....		
5. Bridge gauge readings of bearings:		

	Present reading.	Original reading.	Difference.
No. 1 bearing.....	.....	.....	.....
No. 2 bearing.....	.....	.....	.....

6. Bearings, rebabbitt and machine, as necessary:			

Bridge gauge readings.	Present reading.	Original reading.	Difference.
No. 1.....	.....	.....	.....
No. 2.....	.....	.....	.....

7. Impeller and impeller shaft, remove from casing:		
(a) Condition of key.....		
(b) Machine work (or renewal).....		
(c) Shaft sleeve, machined, renewed.....		
8. Diffusion vane plate or ring (if pump is multistage):		
(a) Remake the joints between vanes and casing as necessary.....		
(b) Center the diffusion vane plates or rings in the pump casing to correspond to original drawings..		

	Done.	Not done.
9. Channel rings (if pump is multistage):		
(a) Machine or renew as necessary the packing between the ring and impeller or impeller shaft.....		
(b) Center the channel ring in the pump casing in accordance with original drawings.....		
10. Alignment:		
I. Center line through driving engine bearings, extend it through and secure it clear of the impeller bearings....		
II. Take measurements.....		

	Radius of shaft.	Distance between line to bottom of bearing.
No. 1 engine bearing.....	.....	.....
No. 2 engine bearing.....	.....	.....
No. 3 engine bearing.....	.....	.....
No. 1 gear bearing.....	.....	.....
No. 2 gear bearing.....	.....	.....
No. 1 impeller bearing.....	.....	.....
No. 2 impeller bearing.....	.....	.....

III. Shim up and turn pump casing to bring it in alignment on the wire.....		
11. Replace shafts and check coupling faces; remove shafts and machine faces to true them up if necessary.....		
12. Center impeller in casing and secure thrust collar or bearing...		
13. Reassembly. Reassemble the driving engine and pump, taking care to—		
(a) Fit and secure the diffusion vanes.....		
(b) Secure the impeller firmly on the shaft.....		
(c) Secure the sleeves firmly on the shaft.....		
(d) Properly center and secure the impeller and the pump casing and not to pull out of adjustment by bolting up coupling.....		
(e) Fit and lubricate as necessary the stuffing box and seal packing.....		
(f) Secure the shaft coupling.....		
14. Run the pump at full load:		
(a) Examine for leaks.....		
(b) Secure balance weights as necessary to rebalance....		

Assemble drawings.

14–62. When repairing or making an interior examination of a pump it is essential that all drawings and available dimensional data relative thereto be at hand. It is not infrequent that such important dimensions as bridge gauge readings of bearings, clearance between impeller and casing, steam or water seal or gland adjustment become altered, resulting in poor operation. Such poor operation will naturally continue in spite of other major repairs unless the real cause of trouble is rectified.

The packing of the stuffing box.

14–63. The packing around the shafts of rotary pumps may be either the stuffing box type or the labyrinth type. As an additional precaution against entrance of air to the pump, seals filled with steam or water are installed on the shaft. The shaft revolving at a high speed throws the sealing medium out against the gland casing completing the seal. Failure to supply the packing of the stuffing box type or seals with the sealing and lubricating medium, steam or water, as designed, may result in the packing heating up from excessive friction, becoming seriously damaged and scoring the shaft or channel rings of the seal.

It is a fairly easy matter to renew the packing in the packed or stuffing box type of seal, but care should be taken to insure that it is not put in too tight. It is a good plan to thoroughly coat the

packing before inserting it with Albany or other similar grease. The integrity of the packing is likewise further preserved by taking a finishing cut off the shaft to remove any grooving that might tend to injure the packing.

Should labyrinth type packing become damaged to the extent that renewal is necessary the packing box and the shaft must be removed so that they can be swung in a lathe. Cut out the damaged packing with a cutting-off tool and true up the grooves for the new packing. Bend the packing, which comes in strips about 6 inches long, to the radius of the packing box and insert it in the grooves, driving it in until it is hard up. A convenient tool for use in driving in is a tuning-fork-shaped swage, two or three inches wide, with edges curved to the radius of the gland box or shaft and grooved sufficiently so that it will slip easily over the section of the packing. When the packing is hard up in the groove in the box the bottom edges of the tool will just clear the gland box or shaft. Now calk the packing box or shaft into the soft metal of the packing so as to anchor it. Adjacent ends of the sections of packing must be separated by 0.012 inch to allow for linear expansion. The gland box or shaft is placed in the lathe and the packing turned to the proper diameter and contour as shown on the drawings.

Labyrinth packing that is worn due to wear of bearings should only be renewed when the bearings are rebabbitted. Frequent examination during each watch must be made of the water or steam supply piping to the packing seals to insure that they are kept clear.

Renewal of bushings.

14–64. Whenever the pump casing is opened the clearance of the various bushings between casing and various parts of the impeller and shaft to prevent leakage from one element to another should be measured to see if excessive wear has taken place and if renewal is necessary. Should the bearings be worn down excessively it is reasonable to expect that renewal of the bushings is necessary. They should not be renewed, however, unless the pump bearings that may be down first be brought up to their original bridge readings.

14–65. The bearings of centrifugal pumps should be rebabbitted, where they are down the amounts as indicated by bridge gauge readings, in accordance with the table in chapter 39.

The oil clearance that should be given bearings will be found in the table of tolerances and clearances, chapter 39.

Emergency rebabbitting of small bearing.

14–66. An ingenious method of rebabbitting a small bearing in an emergency is to coat the journal heavily with banana oil and, with the shaft properly centered in the bearing housing, pour the babbitt around the journal. The bearing will break clean from the journal and can then be used with little or no scraping in.

Lignum-vitæ bushings.

14–67. When lignum-vitæ bushings are used for bearings they should be well soaked before fitting. With failure to do so, there is a likelihood of the wood swelling to such an extent as to bind and score the shaft. Soaking the lignum-vitæ 48 hours before fitting will give it a minimum time to swell. When an emergency makes it impossible to soak the wood before fitting, ample clearance must be left to allow for swelling. The clearance that should be allowed in lignum-vitæ pump bearings (wood having previously been soaked) will be found in the table in chapter 39.

NOTE:—To prevent cracking, spare lignum-vitæ bearings and lignum-vitæ to be used for bearings should be stored immersed in water.

Keyed sleeves and impellers.

14–68. Frequent trouble is experienced from the impeller coming loose on the shaft because of a key corroding or otherwise working out. Monel metal keys do not corrode and have given good results. Zincs fitted in a pump chamber will reduce corrosion and securing the keys on the runners with sets screws will tend to keep them in. Some pumps have a steel shaft protected by a composition sleeve keyed to it. The same trouble may be expected with the keyed sleeve as with the keyed impeller. Shaft sleeves should be put on with a driving fit; the tolerances to obtain such a fit will be indicated in chapter 39.

Discharge orifices to plumb channel.

14–69. It is essential to the economy of a centrifugal pump that the discharge orifices of the impeller plumb the channels in the diffusion vane plates or rings, otherwise uneconomical eddies and friction losses will be set up in the flow of water through the pump. Care should be exercised that the diffusion vane plates or rings are set in the casing in exact accordance with the drawings and that the impellers are secured to the shaft so as to plumb axially the channels between the vanes. In assembling the pump the thrust bearings or collars must be adjusted so as to secure the impeller channels and diffusion vane channels in perfect alignment.

Channel ring.

14–70. The channel rings in multistage pumps must be fitted properly in the pump casing to prevent leakage between stages. Likewise the packing or bushings used to prevent leakage along the shaft should be repaired when necessary to keep up the efficiency of the pump. Packing of the bushing or radial labyrinth type should not be renewed unless the pump bearings are up to the original bridge gauge readings.

Aligning driving engine and pump.

14–71. A good method to line up a driving engine and pump is first to break down both and remove the shafts. Use either the driving engine or the pump as the basis of alignment dependent upon which of the two is allowed the least freedom of movement by its pipe connections. Run a piano wire from a finger piece secured on the bearing of the basis of alignment farthest from the other part of the unit, through the bearings of both the driving engine and pump, to a point clear of the other part of the unit. Center the line on the bearings of the basis of alignment and then move from side to side or shim up in place the other part of the machine until the line centers its bearings. Lay the shafts in place and check the parallelism of the coupling faces with feelers; if the faces are perpendicular to the shaft axis (properly faced off) they should check up true or parallel. When these conditions are fulfilled the pump may be considered in alignment. Care should be taken not to pull the various parts of the pump out of alignment in setting up the holding-down bolts, and by pulling up flanges on connecting piping which do not exactly match up with the flanges on the pump.

Insertion of "dutchman."

14–72. When bolting up the shaft coupling see that a dutchman of sufficient thickness is inserted between the coupling faces so as not to destroy the axial adjustment of the pump impellers or driving engine cranks or rotor blading. This precaution is taken to prevent the impeller being drawn or forced to either side if the flanges do not match up.

Balancing high-speed pumps.

14–73. It may be found when running a pump at high speed that it is not properly balanced and therefore vibrates excessively. Cover a portion of the shaft between the driving engine and pump with powdered chalk and water. Run the pump and locate the high spot on the shaft, where chalked, by using a pencil in the same manner as centering a piece in a lathe; care being taken that the pencil is held

rigid and not allowed to follow the shaft, but just touching the high spot on it. The actual high spot is from 10° to 20° in advance of the pencil mark, dependent upon the speed of the pump, the higher the speed the greater angular advance. Secure balance weights on the fly-wheel or coupling opposite to the high spot. The balance may not be obtained at first, but can be obtained by trial and error.

B.—Gear pumps—Quimby, Electric Boat, Kinney, Rumsen.

PART 1.—OPERATION.

Steps in starting.

14–74. To start a gear pump proceed as follows:

1. Fill all oil cups and reservoirs. If lubricated by a detached pump, open up and adjust all oil-delivery valves at bearings.
2. Open the pump suction valve.
3. Prime the pump.
4. Open the pump discharge valve.
5. Open the engine cut-out (or root) valves in the—
   (*a*) Steam line.
   (*b*) Exhaust line.
6. Open the exhaust valves at the driving engine.
7. Open the driving engine drains.
8. Crack the engine throttle valve, then slowly open it so as to admit steam gradually.
9. Close the driving engine drains when the engine is clear of water.
10. Such additional instructions as may be necessary for a particular pump will be added hereto by the engineer officer.

Steps in stopping.

14–75. To stop a gear pump proceed as follows:

1. Close the driving engine throttle valve.
2. Close the driving engine exhaust valve.
3. Open the driving engine drains.
4. Close the pump suction valve.
5. Close the pump discharge valve.
6. Close all oil delivery valves at the pump and engine bearings.
7. Close the driving engine steam and exhaust cut-out (or root) valves.
8. After the driving engine is drained, close the steam drains unless they are connected to a common drain line running to a tank.

Speed of pump.

14–76. The speed at which a gear screw pump should be operated is dependent upon the desired quantity and pressure of the discharge. These can be varied within the wide latitude that this design of pump permits without much danger of breakdown.

Priming.

14–77. (1) Gear pumps, the working parts of which have the designed clearances, find no difficulty in taking suction lifts and therefore seldom need to be primed before taking suction. As the parts become worn, however, it frequently happens that gear or screw pumps take a suction with difficulty and sometimes must be primed. For methods of priming see art. 14–53.

Glands.

14–78. Particular care must be taken to see that the glands around the pump shafts are not set up so tight as to cause the stuffing box to bind and score the shafts. At the same time, however, if a gland is not set up tight enough, air will be drawn into the pump, cutting down its efficiency. Where the pump has a suction lift it is advisable to keep a slight leakage from the stuffing box. This will insure lubrication of the shaft and at the same time indicate that air is not being drawn into the pump.

14–79. To operate the driving engine properly reference must be made to the instructions elsewhere in the manual covering the class of the machine in question.

PART 2.—CARE.

14–82. For general instructions as to care of rotary pumps see arts. 14–55 to 14–60, inclusive.

PART 3.—REPAIRS.

14–84. Repair guide lists.

_____ *Gear pump.*

*Kind*_____ *Size* _____

*Date*_____

This list is intended to cover the repairs to the pump proper. Those on the driving engine, which should be undertaken simultaneously, are covered by the list for the general class of machinery under which the driving engine belongs.

	Done.	Not done.
1. Assemble drawings.		
2. Collect *previous data.*		
3. Open up the—		
(a) Stuffing boxes and seal		
(b) Pump casing		
(c) Bearings		
4. Stuffing boxes or seals:		
(a) Condition		
(b) Machine work (or renewals)		
5. Bridge gauge readings of bearings:		

	Present reading.	Original reading.	Difference.
No. 1 bearing			
No. 2 bearing			
No. 3 bearing			
No. 4 bearing			

6 Bearings; rebabbit and machine as necessary.

Bridge gauge readings Number 1.	Present reading.	Original reading.	Difference.
Number 2			
Number 3			
Number 4			

7. Measure with micrometer feelers or calipers the clearance between the pump casing and the working parts and between the various adjacent working parts:

Present clearance.	Designed clearance.

8 Working parts; remove from casing:
(a) Condition
(b) Condition of keys and shafts
(c) Machine work or renewal on—
1. Working parts
2. Keys and shafts

	Done.	Not done.
9. Alignment:		
(a) Centerline through driving engine bearings, extend it through and secure it clear of the bearings of the working parts of the pump.		
(b) Take measurements:		

	Radius of shaft.	Distance between line and bottom of bearing.
No. 1 engine bearing		
No. 2 engine bearing		
No. 3 engine bearing		
No. 1 gear bearing		
No. 2 gear bearing		
No. 1 working part bearing		
No. 2 working part bearing		
No. 3 working part bearing		
No. 4 working part bearing		

(c) Shim up and turn pump casing to bring it in alignment on the wire		
10. Replace shafts and check coupling faces, remove and machine faces to true them if necessary.		
11. Reassemby. Reassemble the driving engine and pump, taking care to:		
(a) Fit and securely key working parts on shafts		
(b) Remake the casing joints so that the proper and designed clearance between the casing and working parts is obtained		
(c) Fit and lubricate as necessary, stuffing the box and seal packing		
(d) Secure the shaft coupling		
12. Run the pump at full load:		
(a) Examine for leaks		
(b) Listen for undue friction between working parts		

General instruction. 14–85. The repairs to a gear rotary pump are essentially the same as those to centrifugal rotary pumps except for the pumping units (gear, screws, rotary pistons, etc.). As a general rule, where these become worn or damaged, they must be renewed with spares. Sometimes, of course, in emergencies, the ingenuity of the personnel makes possible temporary repairs to the units so that the operation of the pump may be continued for some time.

Bearings. 14–86. In view of the feature in design of these pumps that the suction is created by two parts working with small clearance with little or no rubbing contact, it is imperative that the integrity of bearings be maintained. Should bearings wear down or otherwise become damaged the necessary accurate alignment of the working parts is lost. It is then but a short time before the working parts will rub and wear with a natural loss of over-all efficiency of the pump.

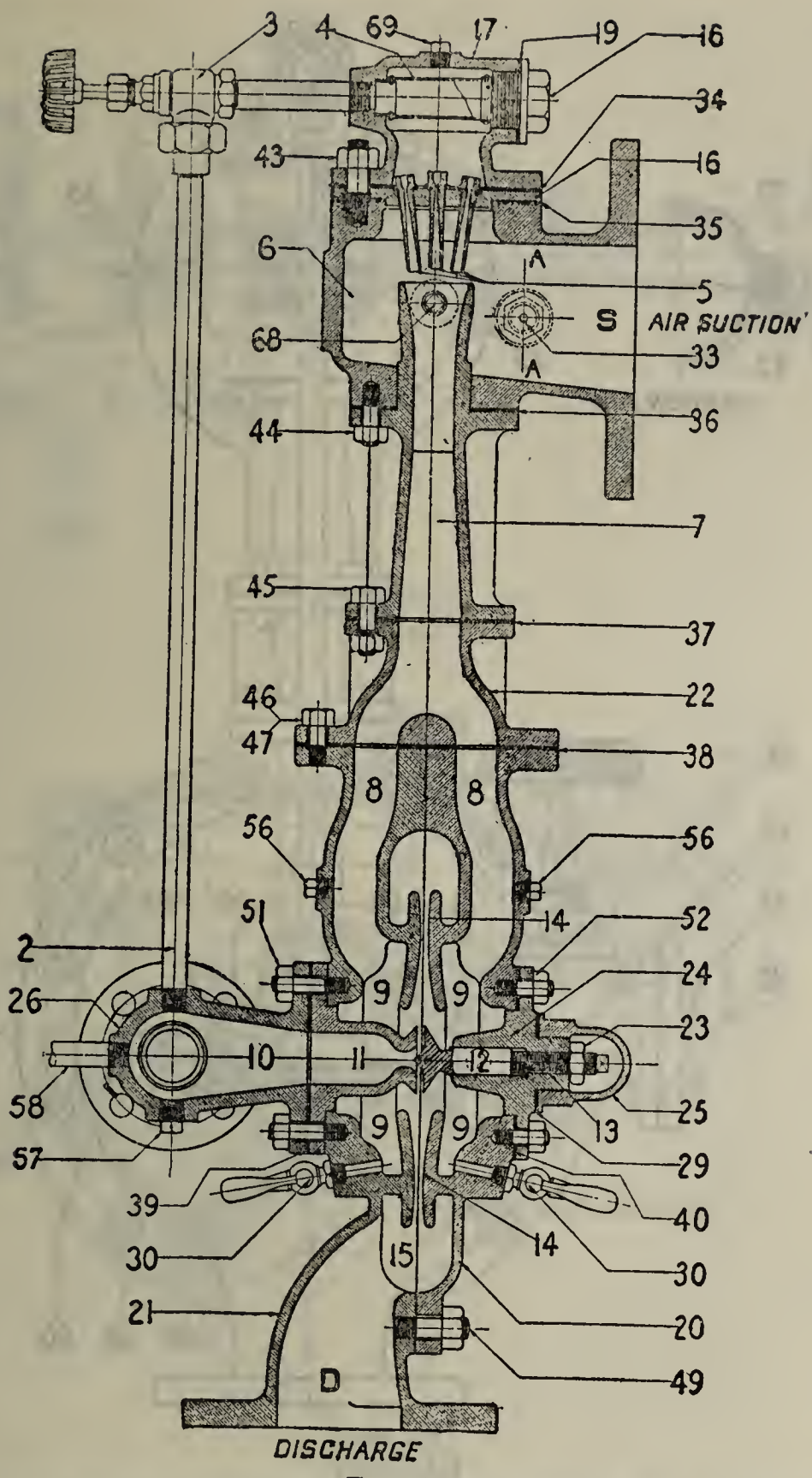


FIG. 14–4.

RADOJET—NOMENCLATURE.

1. Second stage strainer cage.
2. Pipe to first stage.
3. Auxiliary steam valve.
4. First stage strainer cage.
5. First stage nozzles.
6. Suction chamber.
7. First stage diffuser.
11. Second stage nozzle.
12. Second stage nozzle point.
16. First stage nozzle plate.
17. First stage strainer body.
18. Strainer body plug.
19. Strainer body plug gasket.
20. Pump body (nozzle point side).
21. Pump body (discharge side).
22. Elbow pipe.
23. Nozzle point lock nut.
24. Nozzle point guide.
25. Nozzle point cap.
26. Second stage strainer body.
27. Second stage strainer body cover.
28. Gasket (strainer body, cover).
29. Nozzle point cap gasket.
30. Drain cocks.
31. Live steam valve.
32. Companion flange.
33. Orifice plug.
34. Gasket (first stage strainer body nozzle plate).
35. Gasket (nozzle plate suction chamber).
36. Gasket (diffusers suction chamber).
37. Gasket (diffuser elbow pipe).
38. Gasket (elbow pipe pump body).
39. Gasket (second stage strainer body nozzle).

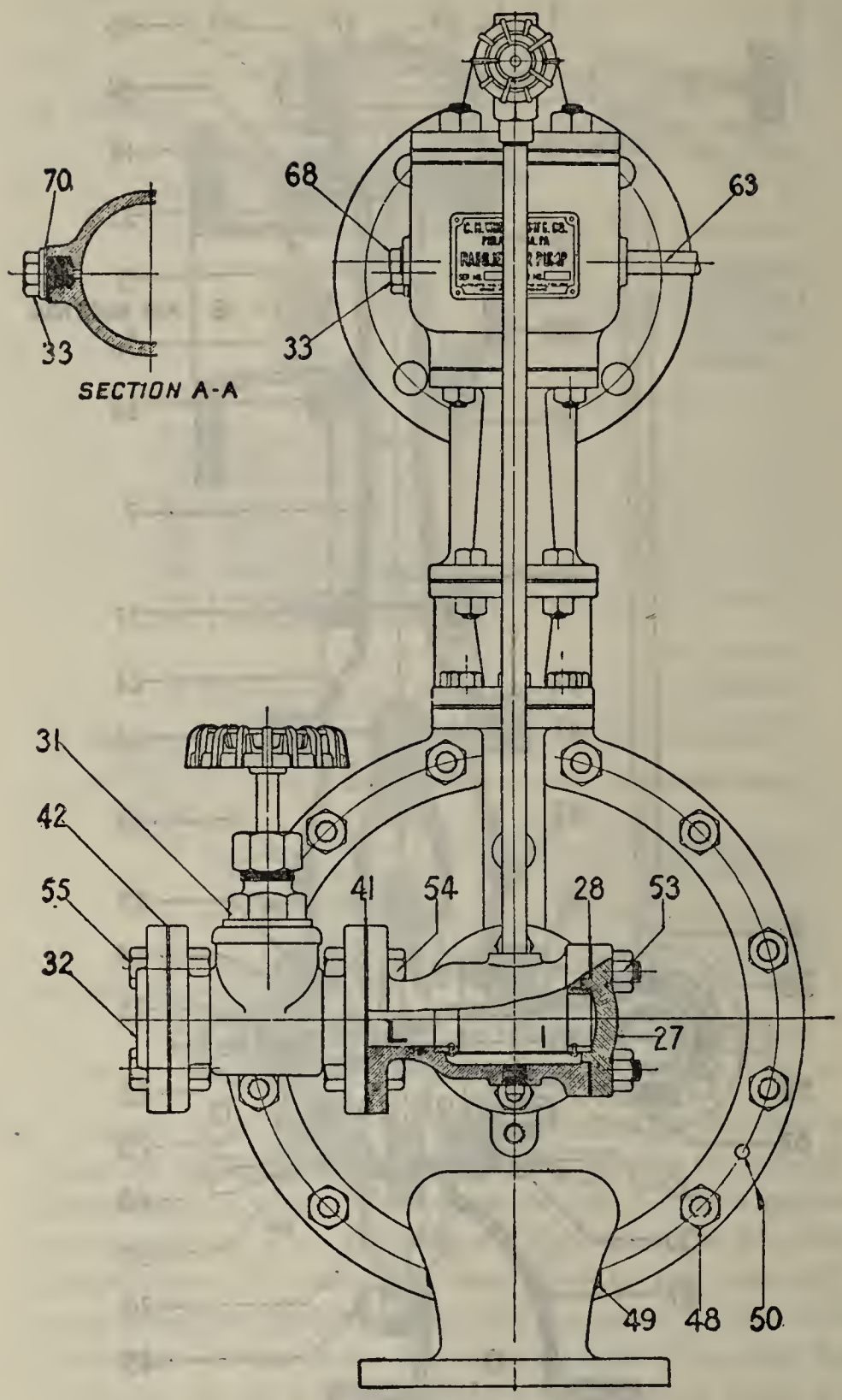
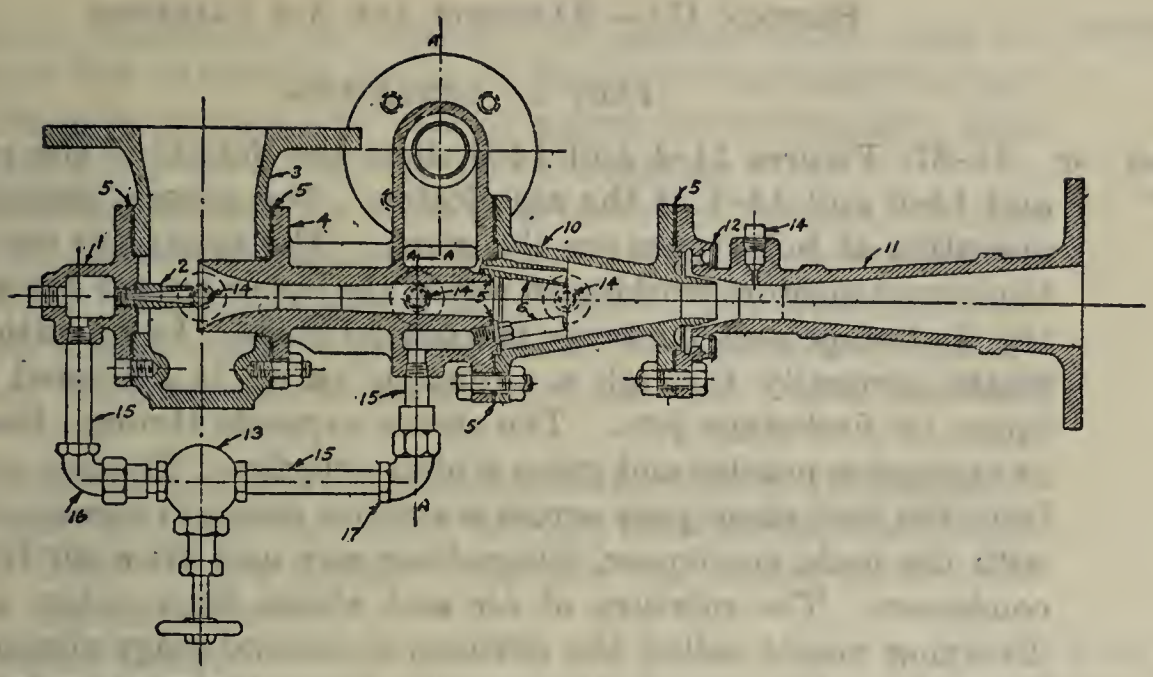


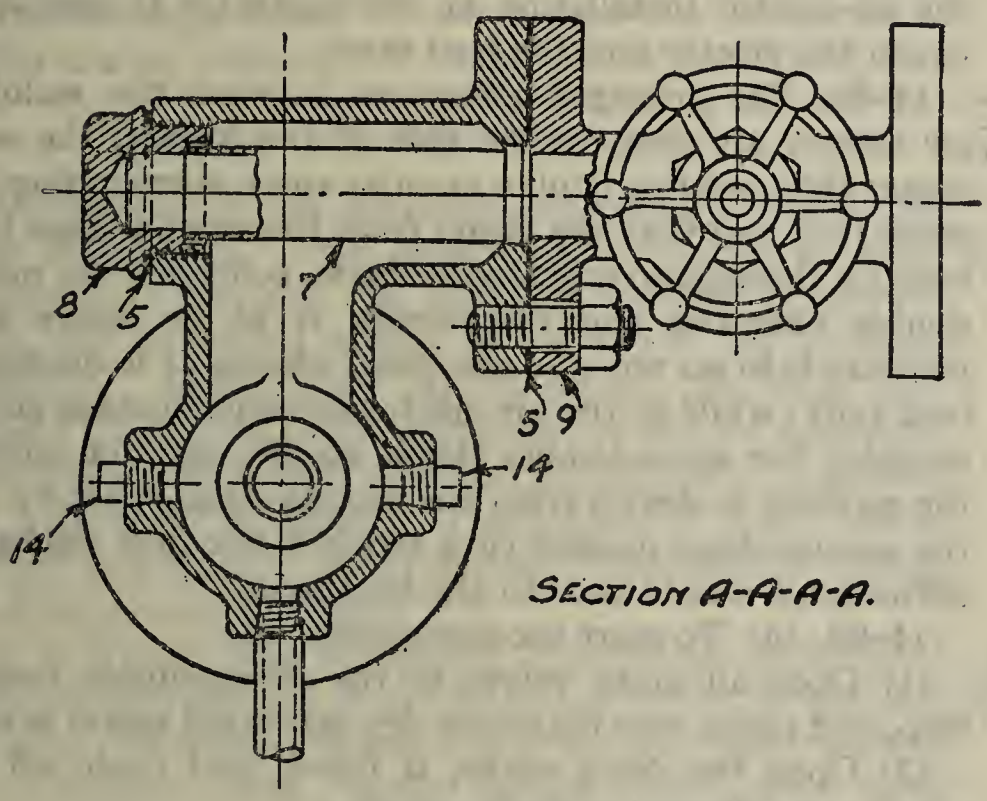
Fig. 14-5.
RADOJET.

40. Gasket (pump body nozzle point guide).
41. Gasket (second stage strainer body live steam valve).
42. Gasket (live steam valve companion flange).
43. Studs and nuts (nozzle plate suction chamber).
44. Studs and nuts (suction chamber diffuser).
45. Bolts and nuts (diffuser elbow pipe).
46. Tap bolts (elbow pipe pump body).
47. Bolts and nuts (elbow pipe pump body).
48. Bolts and nuts (pump body).
49. Studs and nuts (pump body).
50. Dowels (pump body).
51. Studs and nuts (pump body nozzle strainer body).
52. Studs and nuts (pump body nozzle point guide).
53. Studs and nuts (strainer body cover).
54. Bolts and nuts (strainer body live steam valve).
55. Bolts and nuts (live steam valve companion flange).
56. Pipe plug (suction passage of second stage).
57. Pipe plug (second stage strainer body).
58. Nipple for steam pressure gauge.
63. Nipple for vacuum gauge.
68. Pipe plug (vacuum gauge boss).
69. Pipe plug (first stage strainer body).
70. Orifice plug gasket.



AIR EJECTOR.

Fig. 14–6.



AIR EJECTOR.

Fig. 14–7.

NOMENCLATURE.

Item.	Name.	Item.	Name.
1.	Steam chest (first stage).	10.	Mixing chamber (second stage).
2.	Nozzle (first stage).	11.	Diffuser.
3.	Mixing chamber (first stage).	12.	Diffuser screen.
4.	Steam chest (second stage).	13.	Steam valve.
5.	Gasket.	14.	Plug.
6.	Nozzle (second stage).	15.	Pipe.
7.	Strainer.	16.	Union elbow.
8.	Strainer nut.	17.	Union elbow.
9.	Steam valve.		

Section III.—Radojets and Air Ejectors.

PART 1.—OPERATION.

Principles of operation.

14–87. Figures 14–4 and 14–5 show the details of the radojet, and 14–6 and 14–7 of the air ejector. The general principles of operation of both types are the same. The apparatus consists of two steam ejectors working in series, the upper ejector being called the first stage and the lower the second stage. In operation, live steam, generally through a reducing valve, is delivered to the upper or first-stage jets. The steam expands through these jets or expansion nozzles and gains a high velocity. The jets of steam from the first stage pass across a suction space in communication with the main condenser, where they mix and draw air from the condenser. The mixture of air and steam then enters a large diverging nozzle called the diffuser, or second-stage steam chest. Steam from the second-stage nozzles draws the mixture from the second-stage steam chest, or chamber, whence it is discharged past a check valve, either to the atmosphere or to the feed tanks. In the air-ejector installation an air separator is usually fitted between the ejector and the feed tank.

Differences between the radojet and the air ejector.

14–88. The principal differences between the radojet and the air ejector are that, in the case of the former, the second-stage steam chamber is a double annular space surrounding the second-stage jets, and that the steam from the second-stage jets expands radially through an adjustable nozzle, collecting the mixture in the double chamber and discharging it at or above atmospheric pressure into an annular chamber, whence it is discharged to the feed tank; while in the air ejector the second-stage steam chest is straight, the second-stage steam nozzles are not adjustable, and the mixture is drawn from the second-stage chest by steam from the second-stage nozzles in a straight line and discharged into a diffuser, whence it goes to the feed tank.

Starting.

14–89. (*a*) To start the apparatus:

(1) Open all drain valves to the steam-supply lines below the trap, and make sure that only dry saturated steam is supplied.

(2) Open the drain cocks, if fitted, and drain all water that may have collected in the apparatus.

(3) Make sure the valves in the lines to the steam and vacuum gauges are open.

(4) Open full the gate valve in the condenser connection.

(5) Open full the discharge valve.

(6) Close the first-stage steam cut-out valve, and open full the main steam valve. This by-passes the first-stage nozzles and permits raising the vacuum in a shorter time.

(7) After one or two minutes of operation close the drains, if so fitted.

(8) When the vacuum registers above 25 inches, open wide the first-stage steam cut-out valve, and the apparatus is in full operation.

(9) If the ejector heats up so that it will not catch, play a hose on it to cool it off, and repeat the catching operation until discharge is obtained. A 90° elbow directly at the injector discharge, too great a suction lift, suction water too hot, etc., will cause trouble when starting a pump.

Operation.

(*b*) (1) In operation, no attention is required other than to insure that dry saturated steam at or above the minimum designed pressure (usually 115 pounds gauge for the radojet, and 125 pounds gauge for the air ejector) is supplied.

(2) Some installations are fitted with two or more units. Unless there is excessive air leakage, one unit is usually sufficient to maintain the maximum vacuum at full load. On starting, however, both units should be used, if fitted, to shorten the time of raising the vacuum, and to make sure that both are in working order.

(3) When air separators are installed in connection with ejectors, cooling water should be circulated through the air separator before steam is turned on the ejector; otherwise the ejector steam will escape to the atmosphere.

Shutting down.

(*c*) To shut down:

(1) Close the gate valve in the condenser connection.

(2) Close the first-stage steam cut-out valve.

(3) Close the main steam valve.

(4) Close the discharge valve.

(5) Open the drains, if fitted.

PART 2.—CARE AND REPAIR.

Internal causes of faulty operation.

14–90. Both types of ejectors are static, self-contained machines, which need no lubrication. Once adjusted and working properly, they will continue to produce the designed absolute pressure if supplied with dry saturated steam at or above the designed minimum pressure. Should they fail to do so, the cause may usually be traced to air leaks in the condenser, or into the apparatus itself; nozzles eroded, deformed, or fouled with grease; or strainer cages fouled with scale or grease. The apparatus must not be drilled or tapped at any point, as all necessary openings for attaching drains and gauges are provided.

External causes of faulty operation.

14–91. If it is certain that the ejector is in proper adjustment and working order, and still the proper vacuum can not be obtained, it is an indication of improper conditions in the condenser, such as inadequate circulating water, baffles carried away, dirty tubes (either steam or water side); air leaks; or sticking check valves in the discharge line from the ejector to the hot well. Tapping sticking check valves lightly will usually free them, at least temporarily. Checks which give trouble must be opened and cleaned at the first opportunity.

Second-stage nozzle adjustment; radojet.

14–92. The second-stage nozzle-point adjustment is the only adjustment required on the radojet. (See figs. 14–4 and 14–5.) There is no corresponding adjustment on the air ejector. Should it be necessary for any reason to remove the nozzle point (12), unscrew nozzle cap (25), unscrew lock nut (23), and then unscrew the nozzle point after the nozzle-point guide (24) is taken off. To replace, screw nozzle point in, until the shoulder brings up on (24). This is done as a precaution to prevent the face of the nozzle point being jammed against the nozzle (11) when the guide is replaced. Replace guide (24) and make up the joint, using a new gasket if there is any doubt about the condition of the old one. This joint must be securely and finally made at this time because any work on it after the nozzle point is adjusted will affect

the adjustment. Then screw in the nozzle point by means of the square on the end of the spindle until it lightly touches the nozzle (11). Care must be taken that the face of the nozzle point is not scored by jamming it against the nozzle. Back off the nozzle point one-sixteenth of an inch. If a mercury vacuum column is available, attach it to the unused vacuum-gauge boss. (There are two bosses, one on either side of the suction chamber (6).) If no mercury gauge is available, the regular vacuum gauge will have to be relied on. It should be remembered that navy yards and repair ships have facilities for repairing and adjusting vacuum gauges, advantage of which should be taken. A vacuum gauge should be so adjusted as to be correct at the vacuum usually carried. Turn on ejector steam to the first and second stages, with the usual precautions as to quality and pressure. Close the gate valve in the condenser connection. This valve must be tight or a false test will result. The vacuum obtained may be anywhere from 25 to 28 inches. Slightly screw the nozzle point in and out until the highest vacuum is obtained. Then remove test orifice cap, if one is provided, and repeat the nozzle-point adjustment until the highest vacuum is again obtained, then replace the cap. The vacuum thus obtained, stated in inches of mercury and subtracted from the reading of a corrected barometer, gives the absolute pressure, which should correspond with the figures stamped on the cap. These figures show the absolute pressure obtained during the shop test of the radojet.

Cleaning. 14–93. During the first few months of operation, the steam strainers should be cleaned once a week, and thereafter as often as found necessary. Nozzles and diffusers must be cleaned when they become fouled. To clean the first stage nozzles remove the nozzle plate, and soak it in kerosene. Blow out the nozzles with steam, and, if necessary, clean the holes with a soft copper wire or with a wooden stick of the proper size. In the radojet, the second-stage nozzle can be cleaned by removing the nozzle-point guide, being careful not to burr the edges of the nozzle point. To clean the second-stage nozzles of the air ejector, or to clean the diffusers in either type, disassemble the pump body and clean the parts with kerosene. In cleaning, use soft rags. Do not use waste.

Care of nozzles. 14–94. In cleaning, the greatest care must be taken that the shape and size of the nozzles, etc., are not altered in any respect by the use of abrasives or hard materials. This precaution is especially necessary with the second stage nozzle and nozzle point of the radojet. Scores and burrs on these parts, so minute as to be almost imperceptible to the eye will cause a reduction in efficiency.

Reassembling. 14–95. In reassembling, care must be taken that all gaskets are in good condition, and joints properly made and set up; otherwise there will be air leaks. In the radojet do not use gaskets where ground joints are provided, such as between pump bodies (20) and (21), and between pump body (21) and second-stage nozzle (11). (Figs. 14–4 and 14–5.)

Section IV.—Safety Precautions.

14–98. (1) See that relief valves, where fitted, are tested and that they function at the designed pressure.

(2) Never use a jacking bar to start a pump while the steam valve to the pump is open. (See arts. 14–3 (5) and 14–46 (6).

(3) Care must be taken to prevent a pump losing suction. This is especially important with feed, circulating, and lubricating pumps.

(4) The boiler feed pumps shall not be used for other purposes than those connected with the service of the boilers or feed water, except in cases of emergency; and when not under steam their pistons and valve gear shall be moved every day. (See art. 14–6.)

(5) Whenever practicable certain fire and bilge pumps should be kept for use on fire main only and certain ones for pumping bilges only.

(6) Before securing, flush out a fire and bilge pump by having it pump overboard from a sea suction for a few minutes.

(7) In some vessels pumps have been fitted for use either as auxiliary feed pumps or as fire and bilge pumps. In such cases, in order to avoid the possibility either of admitting salt water to the boilers or of wasting feed water, those pumps regularly used as feed pumps shall have all valves of the salt-water connections wired shut, and those pumps regularly used as fire and bilge pumps shall have all valves of the feed-water connections wired shut, the wiring being removed only in cases of emergency and urgent necessity, or for purposes of examination and test not more frequently than once a quarter.

(8) Where fitted, emergency overspeed trips of auxiliary turbine driving pumps shall be set to trip as follows:

(a) *On constant speed units.*—At 15 per cent above the normal operating speed.

(b) *On variable speed units.*—At 15 per cent above the maximum assigned operating speed.

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